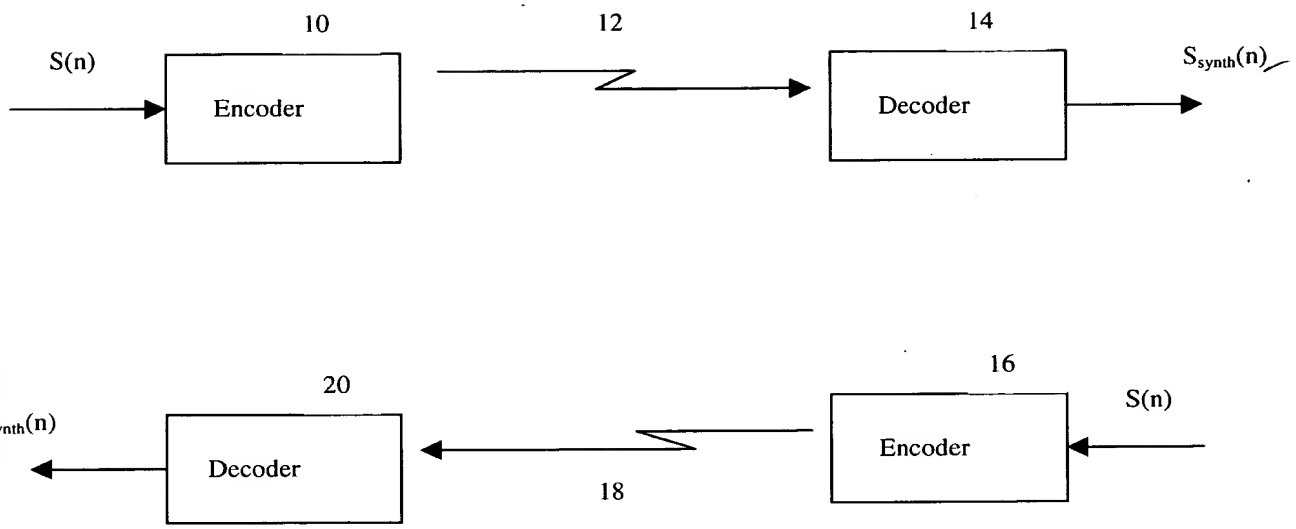
10
12
14
S(n)
Encoder
Decoder
$S_{synth}(n)$
16
20
$S_{synth}(n)$
Decoder
Encoder
S(n)
18

FIG. 1

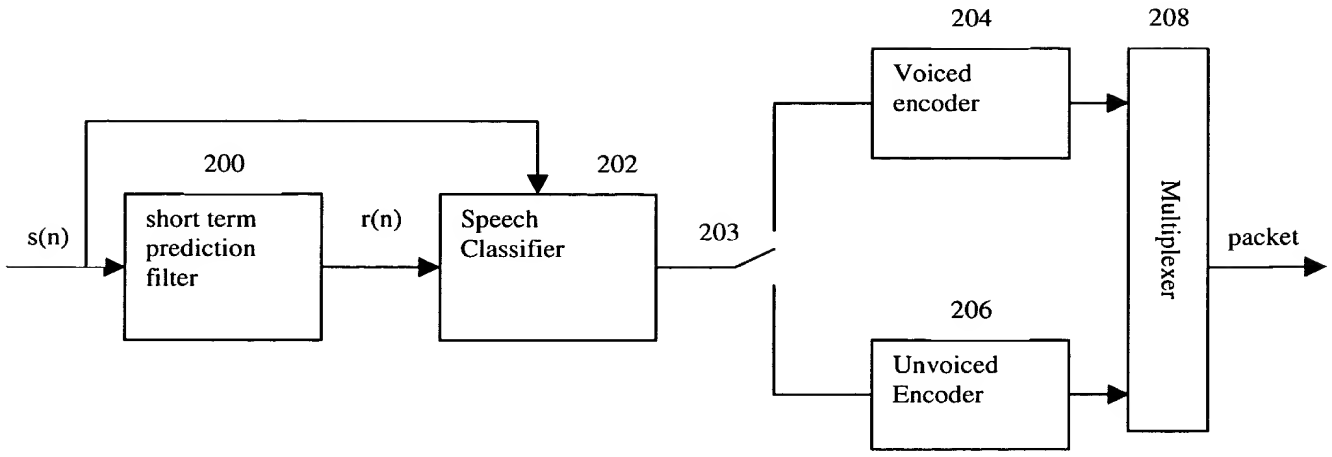
204
208
Voiced encoder
200
202
s(n)
short term prediction filter
r(n)
Speech Classifier
203
Multiplexer
packet
206
Unvoiced Encoder

FIG. 2A

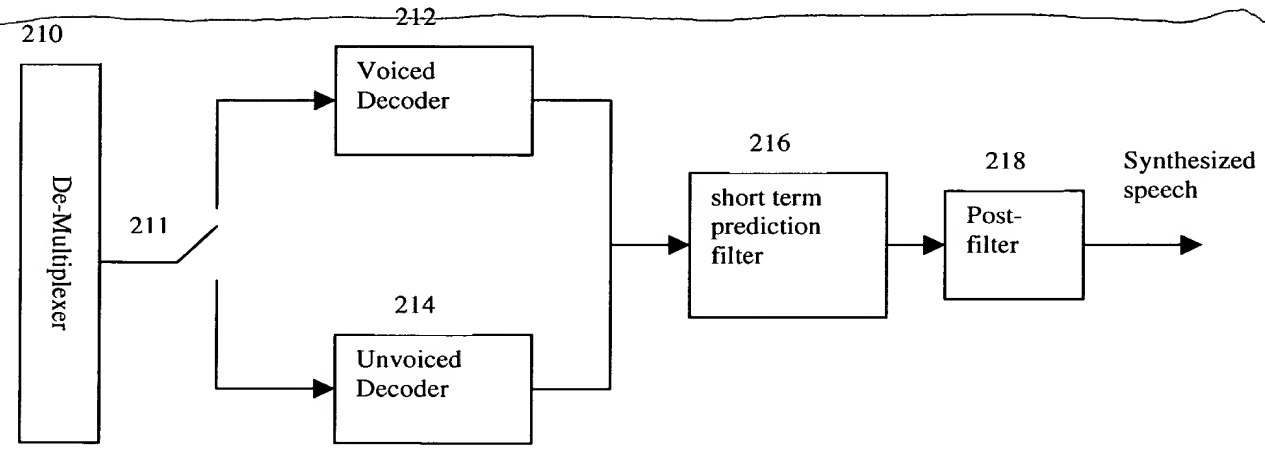
210
212
Voiced Decoder
De-Multiplexer
211
216
218
Synthesized speech
short term prediction filter
Post-filter
214
Unvoiced Decoder

FIG. 2B

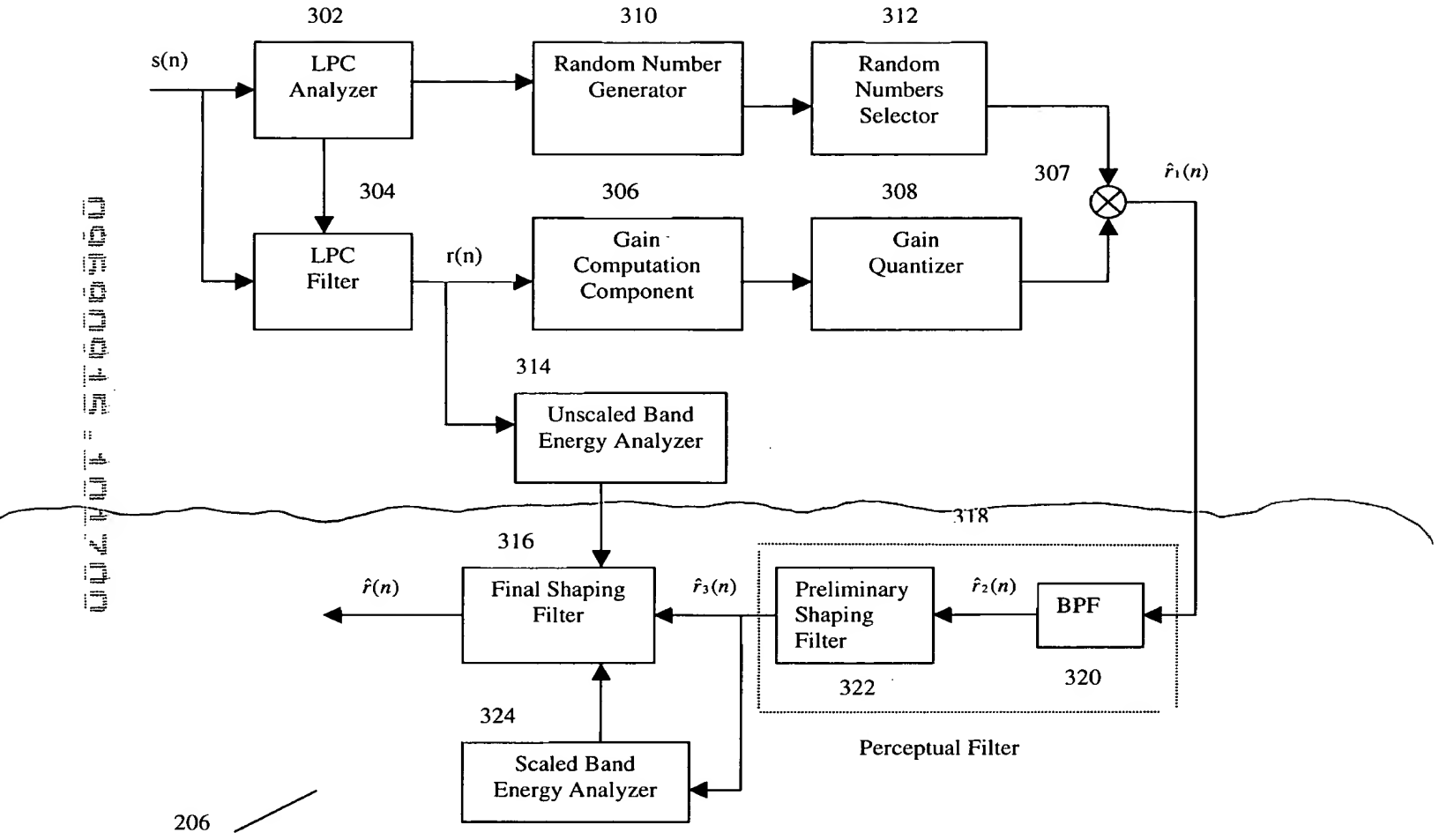
302
310
312
s(n)
LPC Analyzer
Random Number Generator
Random Numbers Selector
307
$\hat{r}_1(n)$
304
306
308
LPC Filter
r(n)
Gain Computation Component
Gain Quantizer
314
Unscaled Band Energy Analyzer
318
316
$\hat{r}(n)$
Final Shaping Filter
$\hat{r}_3(n)$
Preliminary Shaping Filter
$\hat{r}_2(n)$
BPF
322
320
Perceptual Filter
324
Scaled Band Energy Analyzer
206

FIG. 3

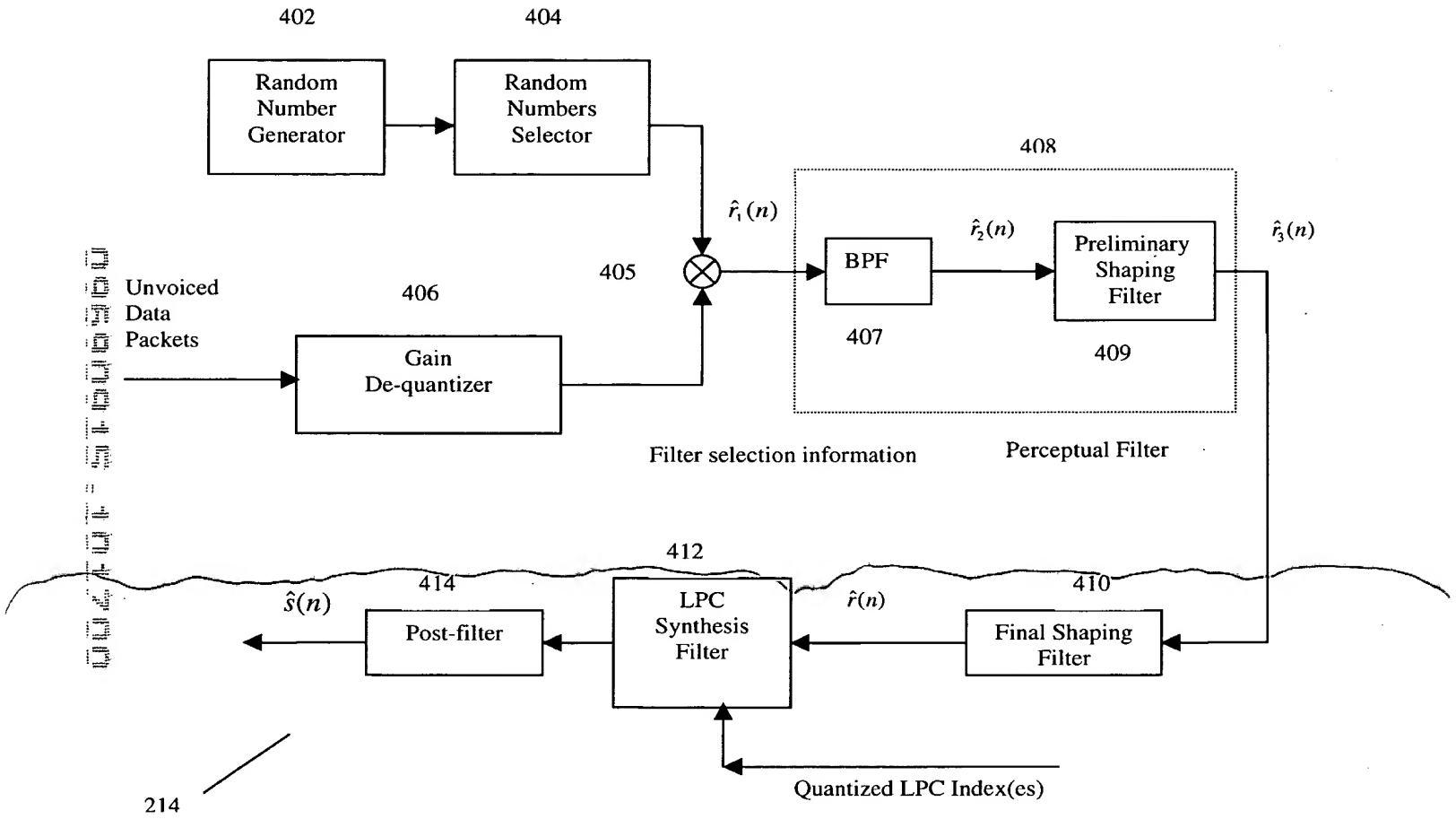
402
404
Random Number Generator
Random Numbers Selector
408
$\hat{r}_1(n)$
$\hat{r}_2(n)$
$\hat{r}_3(n)$
BPF
Preliminary Shaping Filter
405
Unvoiced Data Packets
406
Gain De-quantizer
407
409
Filter selection information
Perceptual Filter
412
414
410
$\hat{s}(n)$
$\hat{r}(n)$
Post-filter
LPC Synthesis Filter
Final Shaping Filter
214
Quantized LPC Index(es)

FIG 4

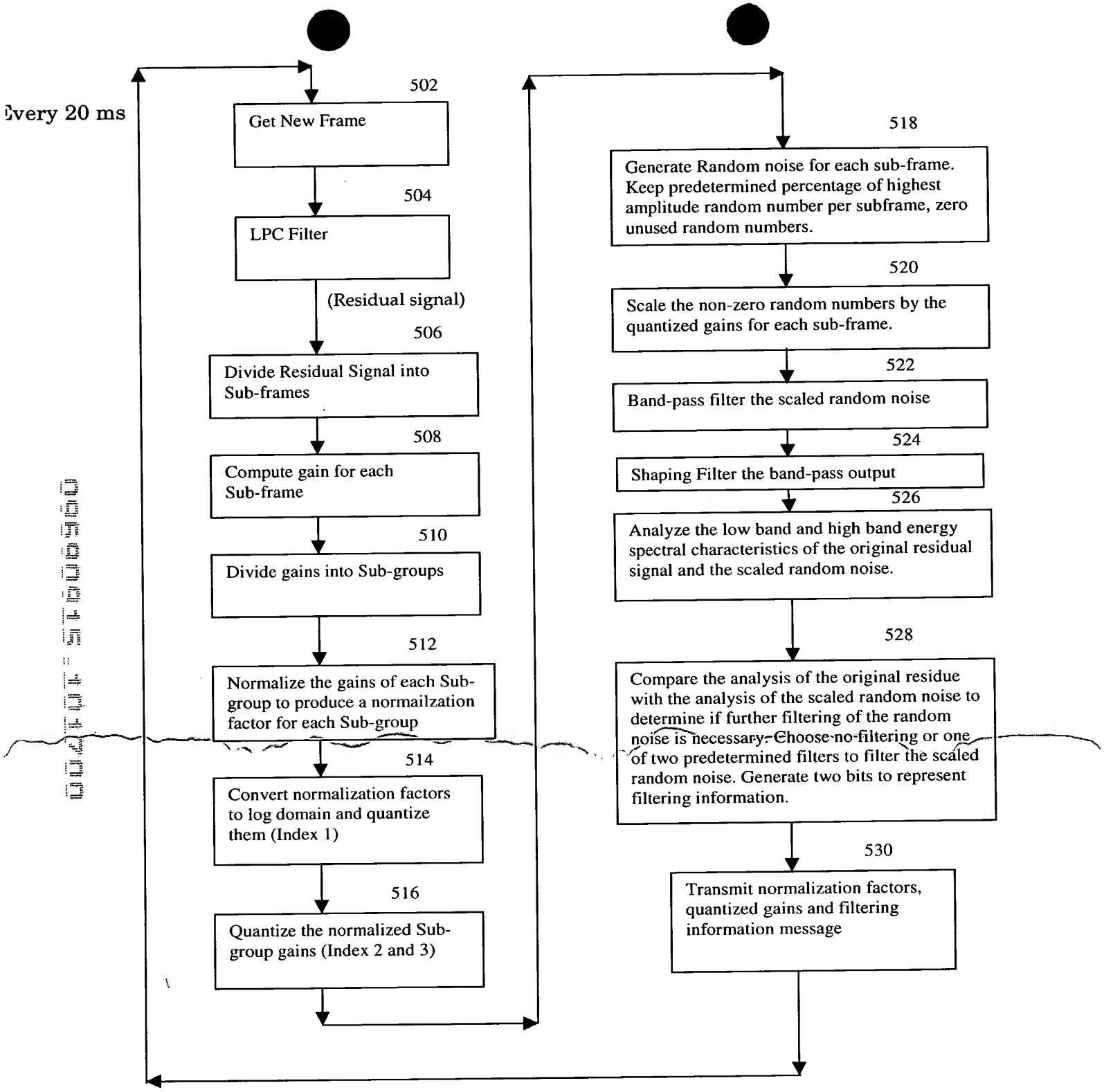
Every 20 ms
502
Get New Frame
504
LPC Filter
(Residual signal)
506
Divide Residual Signal into Sub-frames
508
Compute gain for each Sub-frame
510
Divide gains into Sub-groups
512
Normalize the gains of each Sub-group to produce a normailzation factor for each Sub-group
514
Convert normalization factors to log domain and quantize them (Index 1)
516
Quantize the normalized Sub-group gains (Index 2 and 3)
518
Generate Random noise for each sub-frame. Keep predetermined percentage of highest amplitude random number per subframe, zero unused random numbers.
520
Scale the non-zero random numbers by the quantized gains for each sub-frame.
522
Band-pass filter the scaled random noise
524
Shaping Filter the band-pass output
526
Analyze the low band and high band energy spectral characteristics of the original residual signal and the scaled random noise.
528
Compare the analysis of the original residue with the analysis of the scaled random noise to determine if further filtering of the random noise is necessary. Choose no filtering or one of two predetermined filters to filter the scaled random noise. Generate two bits to represent filtering information.
530
Transmit normalization factors, quantized gains and filtering information message

FIG. 5

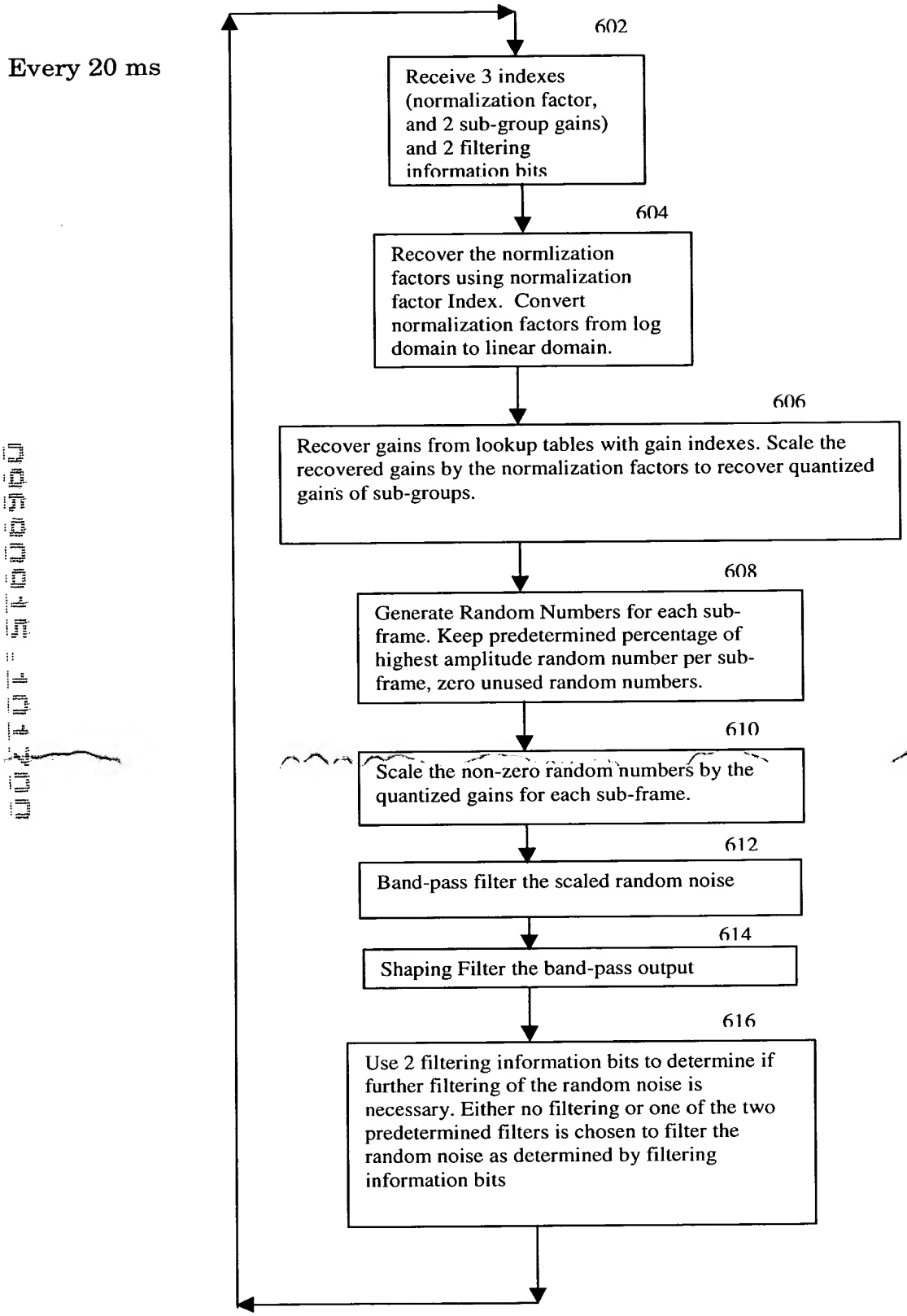
Every 20 ms
602
Receive 3 indexes (normalization factor, and 2 sub-group gains) and 2 filtering information bits
604
Recover the normlization factors using normalization factor Index. Convert normalization factors from log domain to linear domain.
606
Recover gains from lookup tables with gain indexes. Scale the recovered gains by the normalization factors to recover quantized gains of sub-groups.
608
Generate Random Numbers for each sub-frame. Keep predetermined percentage of highest amplitude random number per sub-frame, zero unused random numbers.
610
Scale the non-zero random numbers by the quantized gains for each sub-frame.
612
Band-pass filter the scaled random noise
614
Shaping Filter the band-pass output
616
Use 2 filtering information bits to determine if further filtering of the random noise is necessary. Either no filtering or one of the two predetermined filters is chosen to filter the random noise as determined by filtering information bits

FIG. 6

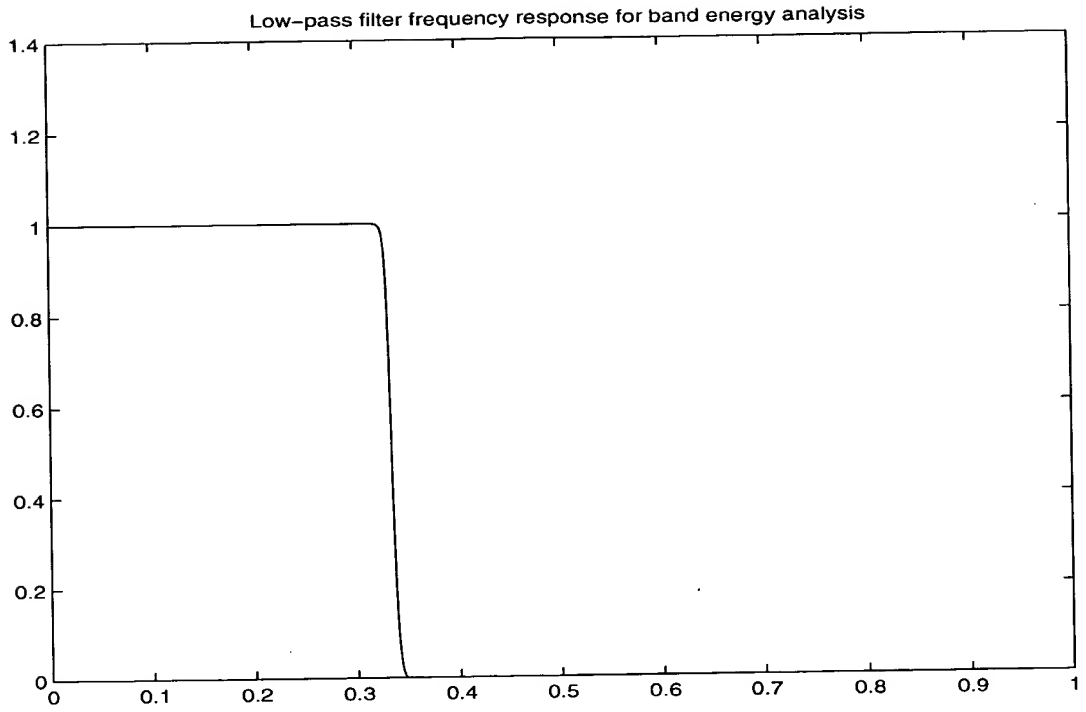
Low-pass filter frequency response for band energy analysis
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

FIG 7A

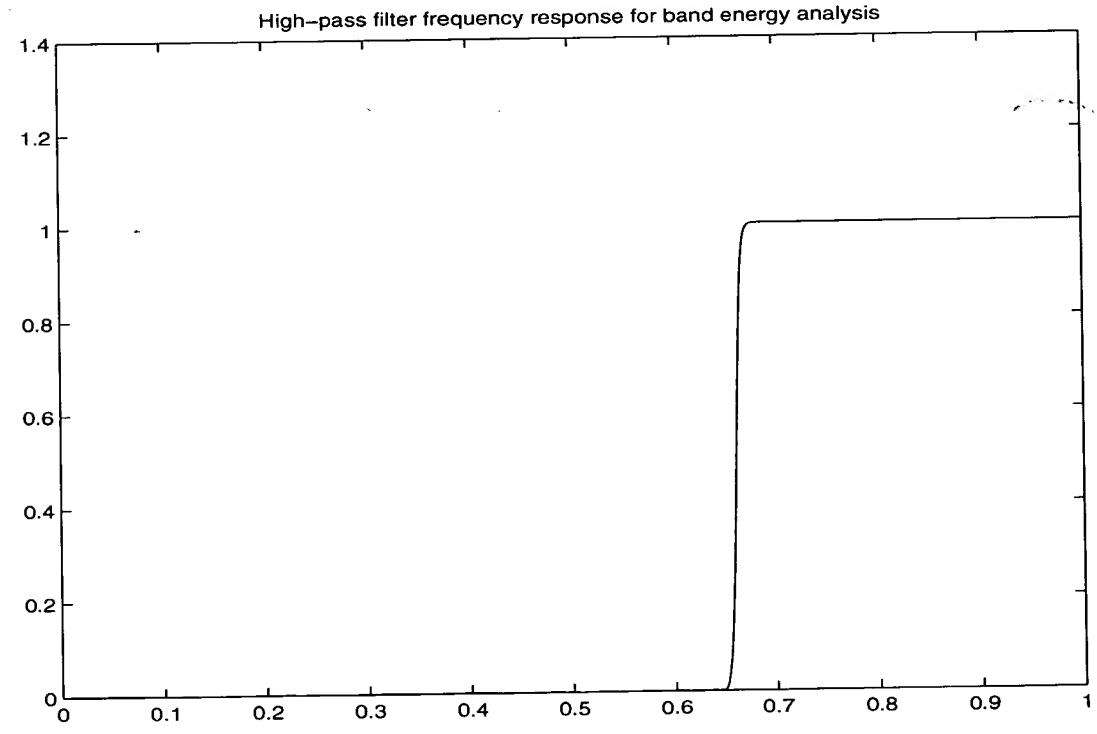
High-pass filter frequency response for band energy analysis
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

FIG 7B

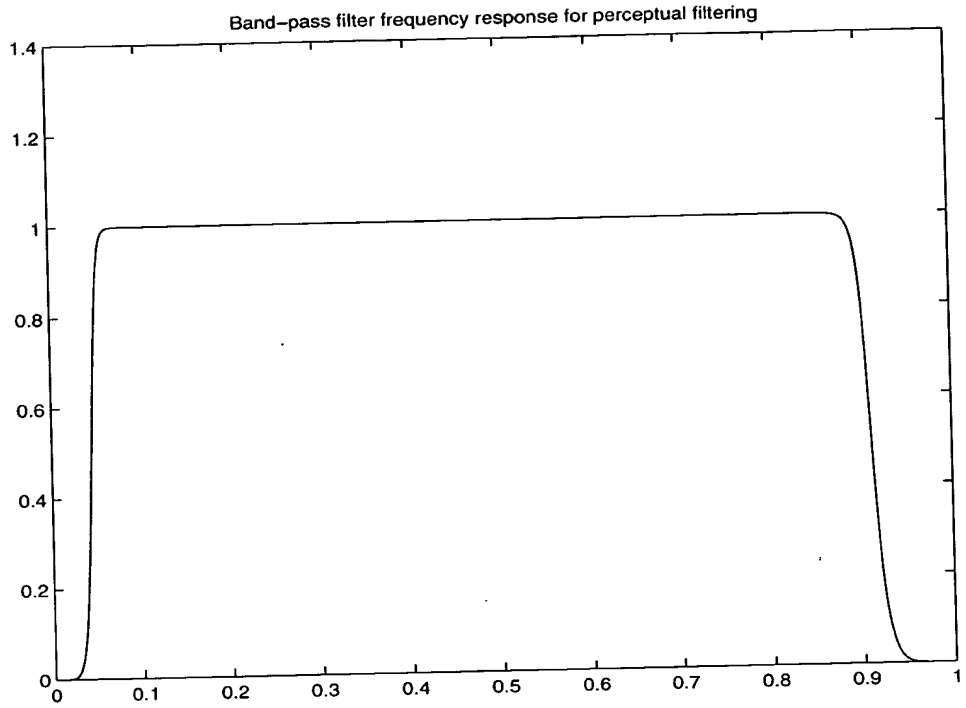
Band-pass filter frequency response for perceptual filtering
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

FIG 8A

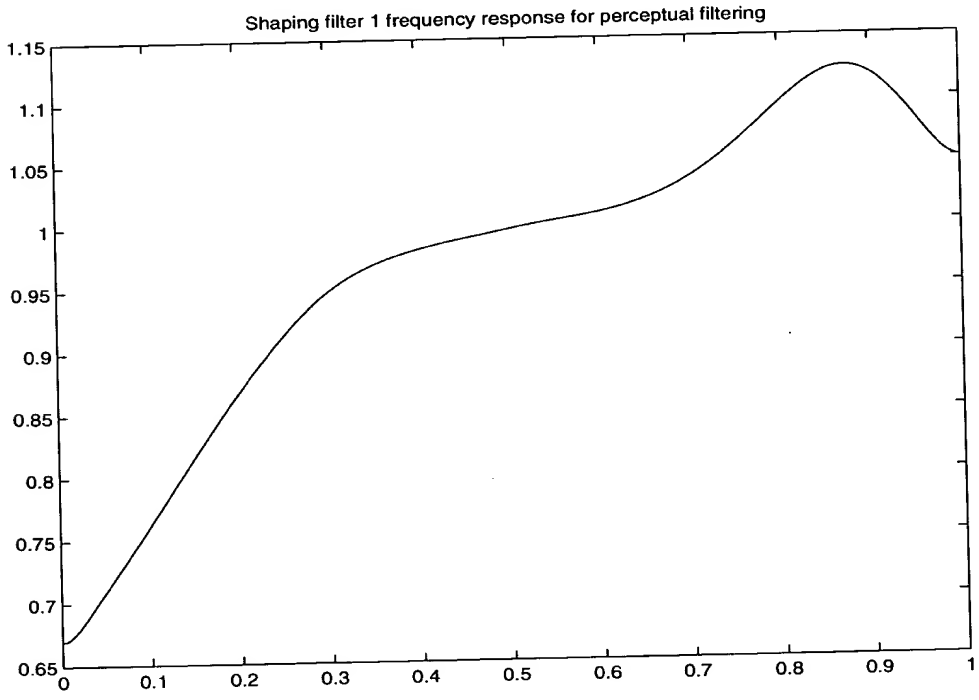
Shaping filter 1 frequency response for perceptual filtering
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

FIG 8B

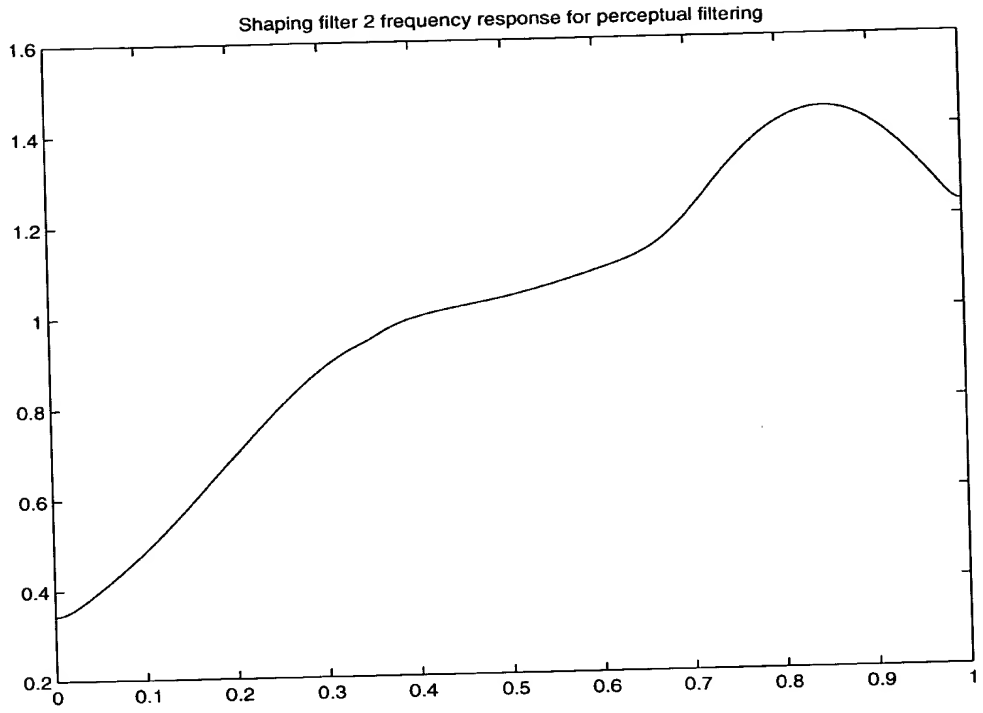
Shaping filter 2 frequency response for perceptual filtering
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

FIG 8C

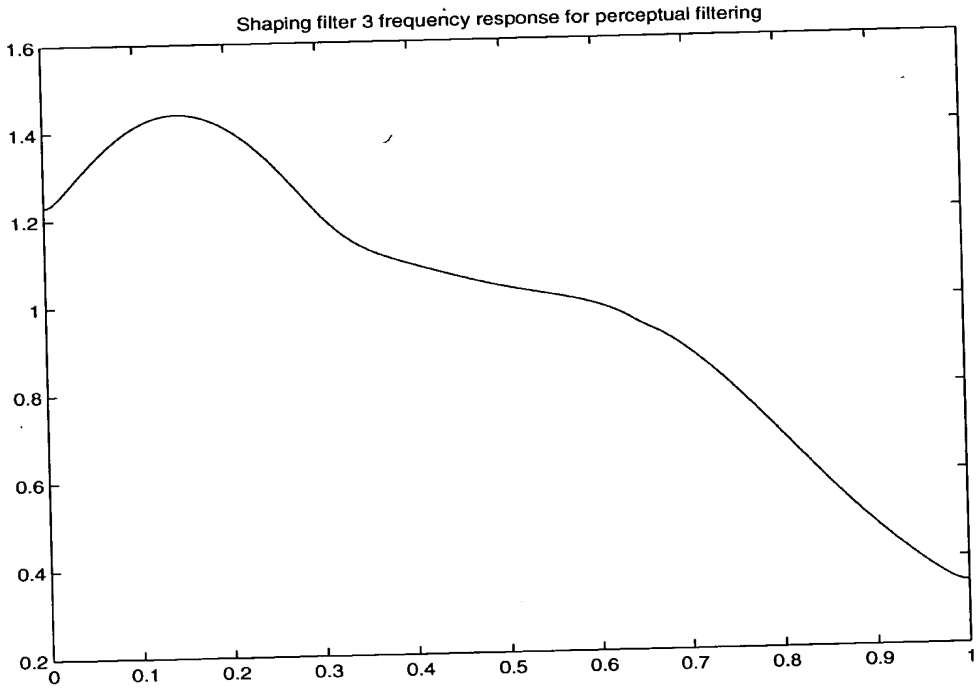
Shaping filter 3 frequency response for perceptual filtering
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

FIG 8D